Booster RF Uptime and Performance

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Abstract

This note summarizes the performance of the booster RF system over the last three years, based on processing logger entries. It is meant to complement and update a similar analysis done in 2005[1][2]. Uptime and average total RF voltage will be presented, as will the up time of individual stations. In addition, tables will be submitted with logger information for the RF sum and individual stations grouped in 15 minute time slots, to aid in further analysis.

1 Data Extraction and Initial Processing

Data for the RF system were extracted from the Lumberjack logger for the years 2008-2010. Specifically, logged values for the total RF voltage (B:RFSUM) and the individual RF gap envelope voltages (B:RFnnGE) were extracted. Data were grouped in 15 minute intervals, and a separate data file was made for each year.

In the case of the gap envelope voltages, the peak was latched prior to logging, and both peak and average values are calculated and stored for each 15 minute interval. They are almost always extremely close, except in the rare cases when the station was toggled on or off during the 15 minute time slot.

The RF sum voltage was a little more problematic. It is logged in two ways: latched on MiniBooNE ($1D) events, and asynchronously sampled at 2 minute intervals. The latched events are more reliable, but are missing when MiniBooNE is not running. To maximize available, both types are read, and the peak found for each 15 minute interval. This reduces the number of missing or anomalously low readings for RFSUM, but there are still roughly 4% of time slots with either no data or an anomalously low reading for RFSUM, even when most or all of the stations are on. The reason for this is not fully understood.

For this reason, the RF uptime will be based on counting how many RF stations are on, since less than 0.1% of the time slots appear to have corrupted records for B:RFnnGE. All RFSUM statistics will be normalized to the total time that the RF system is up *and* had good logger records.

2 Analysis

The combined log records were analyzed and a number of calculations were made both for each year separately and for the entire three year period.

For the global system, the following were calculated:

- The fraction of the time the RF system was up, as defined by at least 12 RF stations with a gap envelope voltage of 20 kV or more (Figure 1).
- The average RFSUM voltage, for times for which RFSUM records were found and the total voltage was at least 200 kV (Figure 2).
- The fractions of this time that this was above 850 kV and 900 kV (Figure 3).
- The number of RF stations up (GE voltage > 20 kV) at any given time (Figure 4).

For individual RF stations, the total down time was calculated, excluding times when the system was down (less than 12 stations up). For example, if a station was down for 2 days before and 1 day after a month long shutdown, the down time would be recorded as 3 days. Also calculated was the longest single down time for each station in the period of time considered (one or three years). This information is summarized in Figures 5 and 6. Because RF station 19 was used as a spare, it was kept off for long periods of time and was therefore excluded from this analysis.

2.1 Discussion and Conclusions

The biggest improvement since the 2005 study is the fraction of time during which at least 18 stations are operating. At that time, there were only 18 good stations active 71% of time[2], while in the period from 2008-2010, there were at least 18 good stations 96% of the time that the system was up. This is the direct and predicted result of using the 19th cavity as a "hot spare". Indeed, that was the major point of the previous study.

Although it's interesting to note that even with the large number of functioning stations, the total RF voltage fell significantly in 2010. It's important to understand this.

On the issue of single station reliability, we see that as before, single long failures continue to play an important role as opposed to routine maintenance (*including PA replacement*). Even over a three year period, we see several cases where the down time for a station is dominated by a single, long failure (Figure 5). In a single given year, this is generally the case for about half the cavities (Figure 6).

Of particular note is station 12, the solid state RF station. We see that again it is among the most reliable stations, but not the best and not dramatically better than average. This is presumably because its down time is attributed to things besides PA failures.

The message is clear: while the solid state RF upgrade should improve booster reliability, it is far from the complete solution to reliability. Adequate spares and technical support are necessary to reduce RF down time.

3 Supplemental material

The following files are stored in the BEAMSDOC database along with this note:

- BRFLogSummary20xx.csv: Spreadsheet with log information for each year, binned in 15 minute intervals as described in section 1. Note, RF stations are numbered 0-18 in the columns.

- BRFLogSummary2008-2010.csv: Same as above for all three years concatenated together. Note that this file is too long to be read with versions of Excel older than 2007.

- BRFDaySummary2008-2010.xls: Average RFSUM by day. The source of Figure 2.

- BRFGlobalLogSummaryByYear2008-2010: A number of calculations for each year and for the entire period. The source of all other figures in the document.

References

[1] E. Prebys, "Booster RF Down Time Analysis", `http://beamdocs.fnal.gov`, BEAMS-DOC-3752-v1 (2005).

[2] E. Prebys, "Benefit of 19th Booster RF Cavity", `http://beamdocs.fnal.gov`, BEAMS-DOC-3753-v1 (2005).

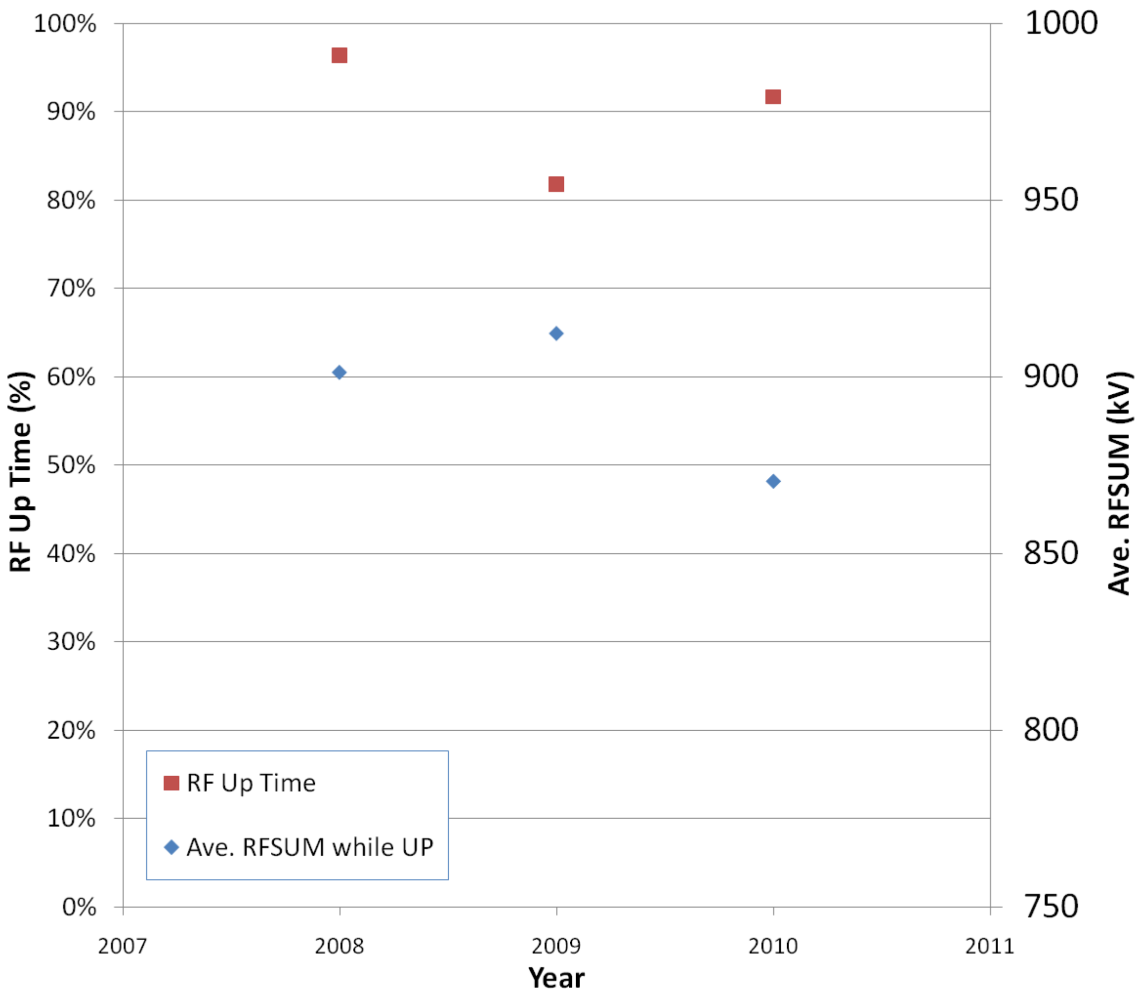

Figure 1: This shows the fraction of the total time that the RF system was up (at least 12 RF stations on), as well as the average RFSUM while up for each year.

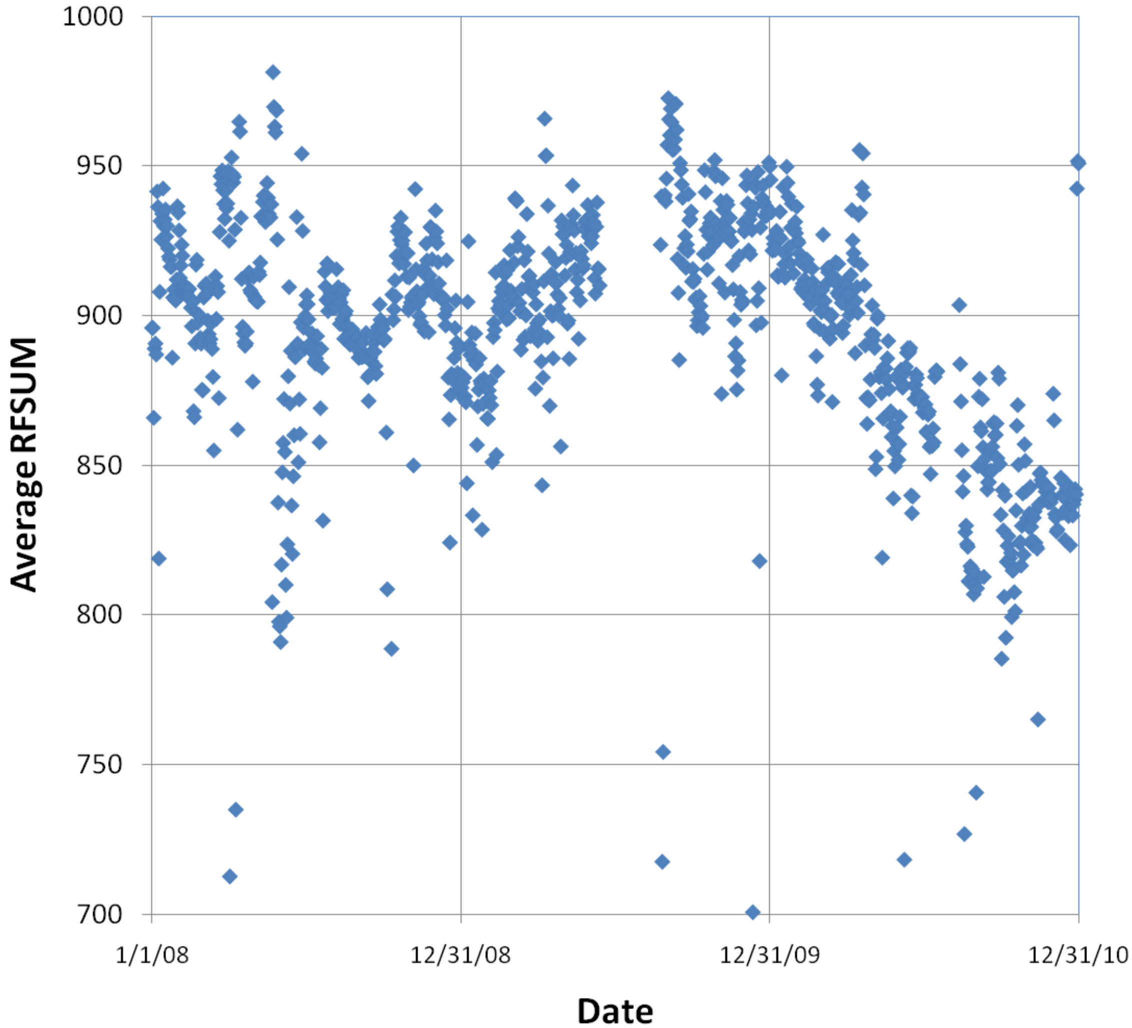

Figure 2: The average RFSUM by day for 2008-2010.

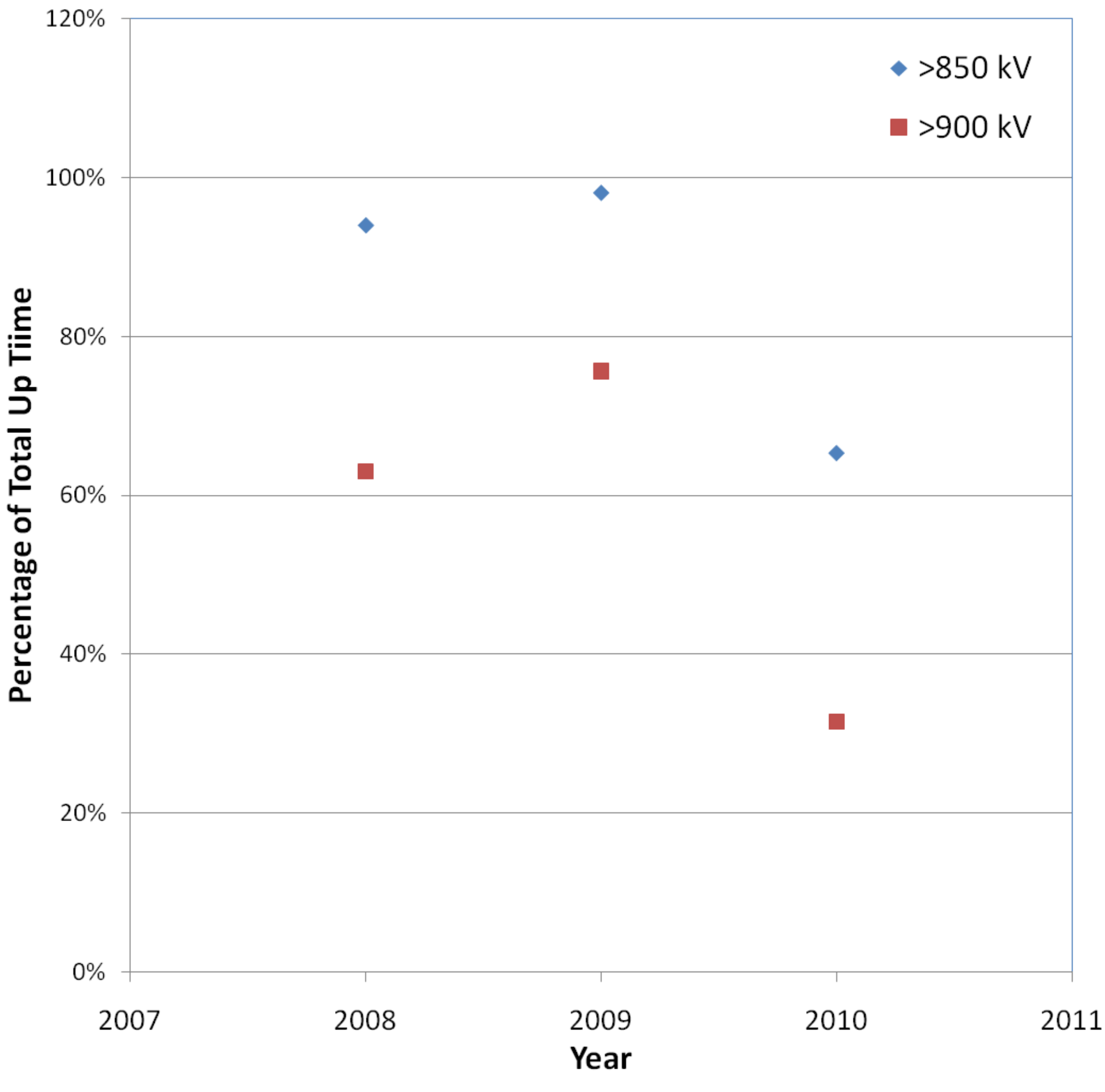

Figure 3: The fraction of time that RFSUM was above 850kV and 900kV while the system was up.

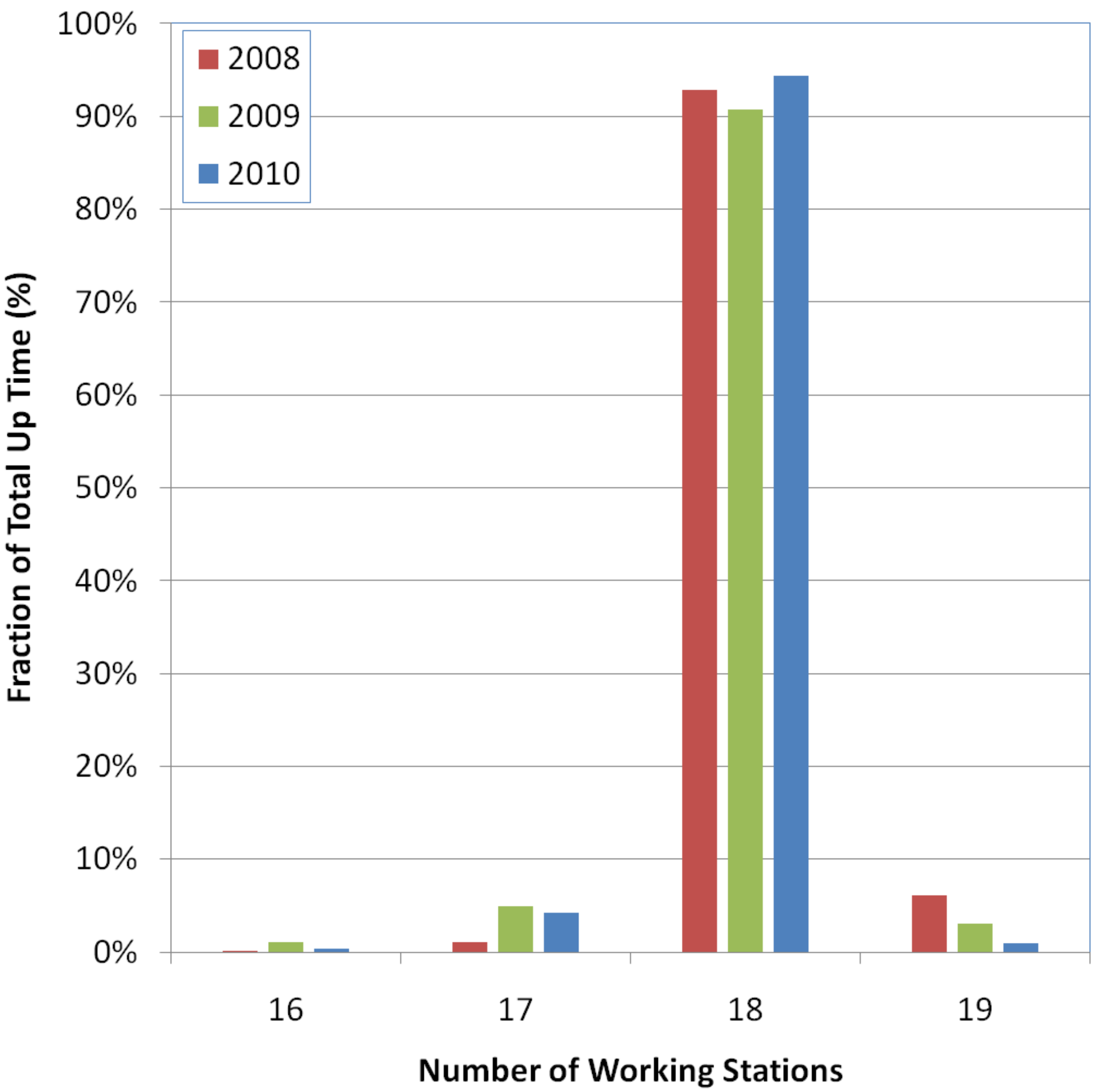

Figure 4: The fraction of the total up time that a particular number of stations were active.

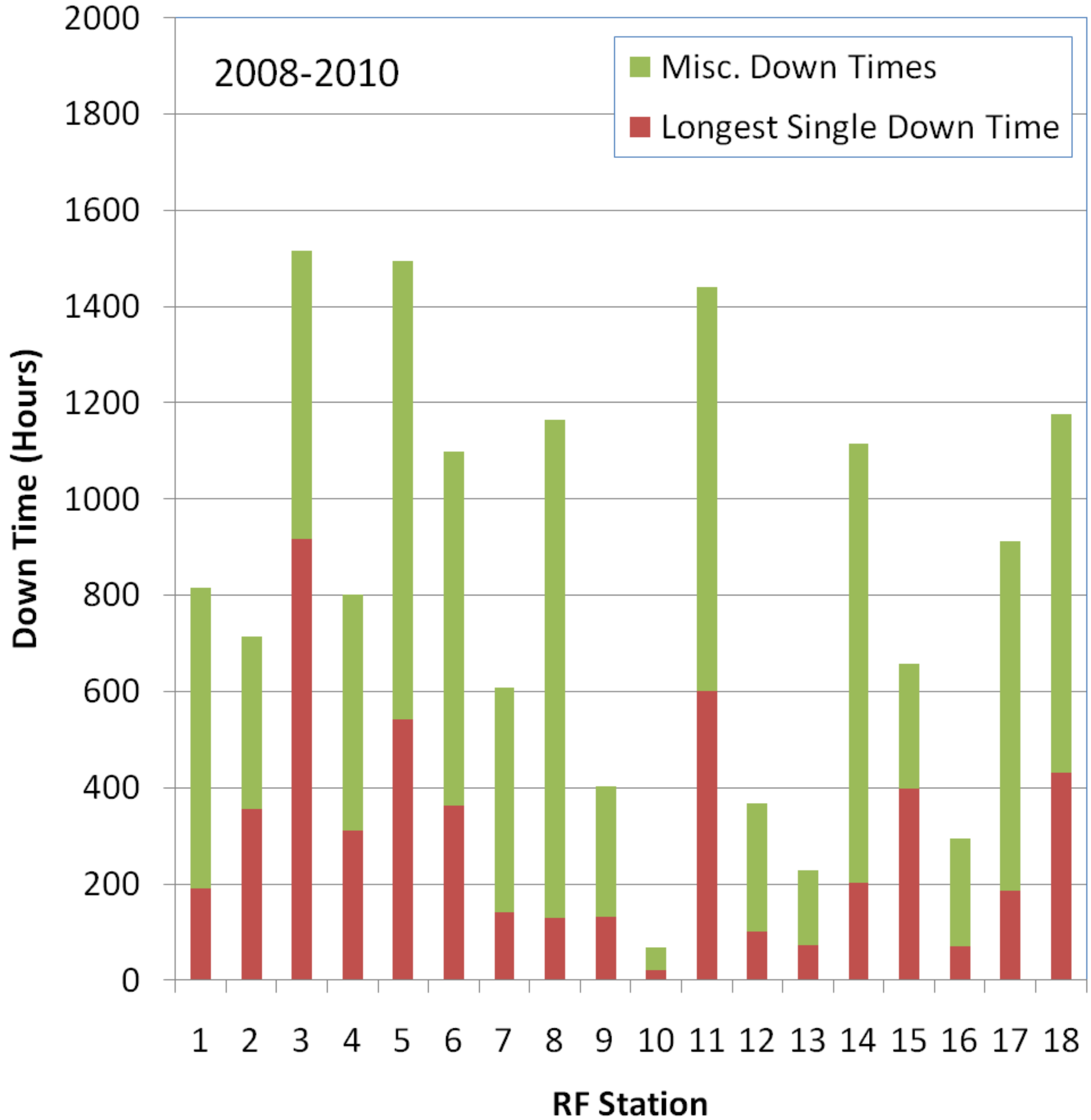

Figure 5: The total down time for each station for 2008-2010. Also indicated is the part attributed to the largest single down time during that three year period.

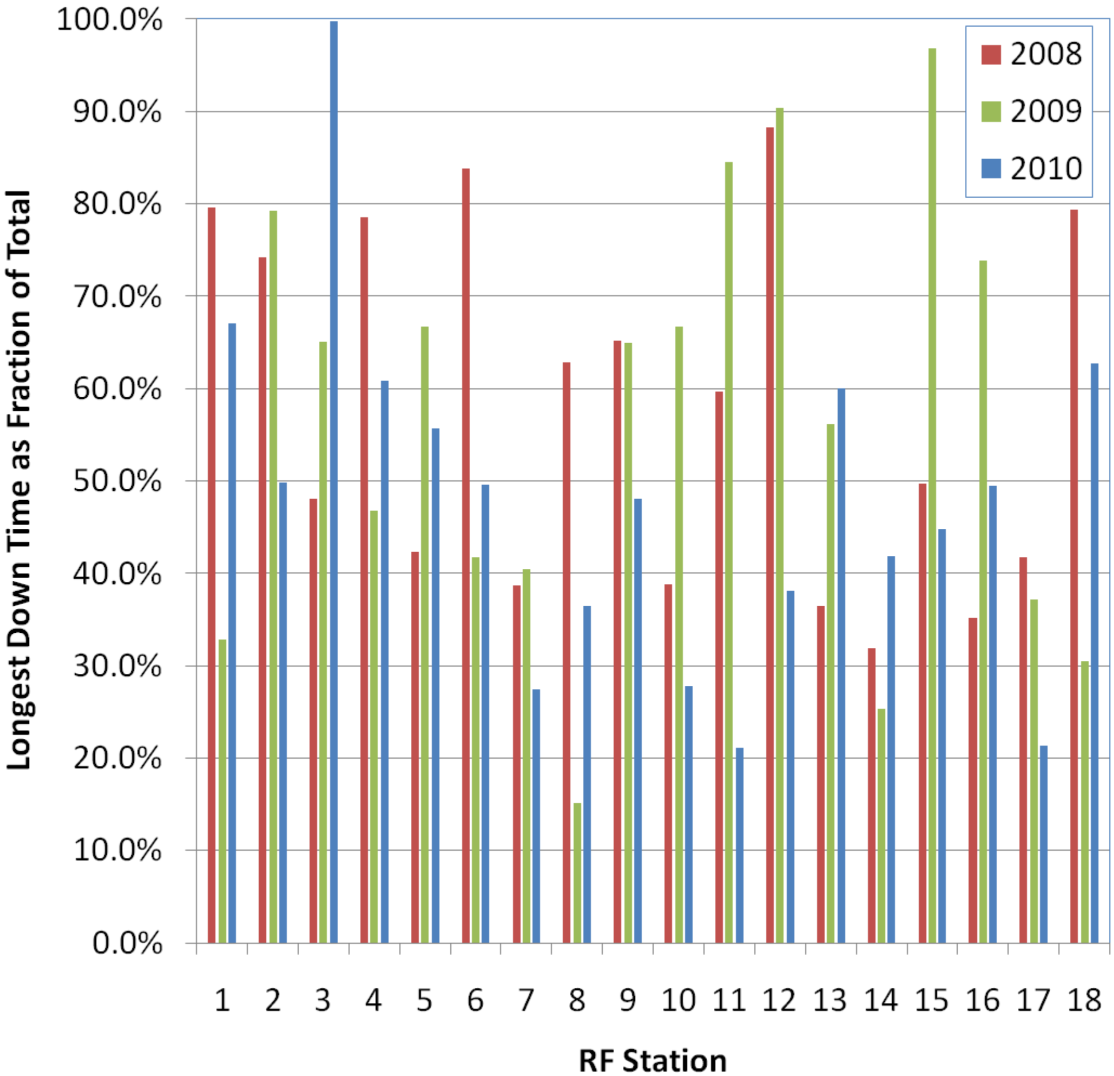

Figure 6: The percentage of the down time attributed to the longest single failure for each year.